

# AI for Urban Climate: Using EO-Based and Community data for Air temperature downscaling at Urban Scales



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Motivation

# Extreme Heat Context and Risks

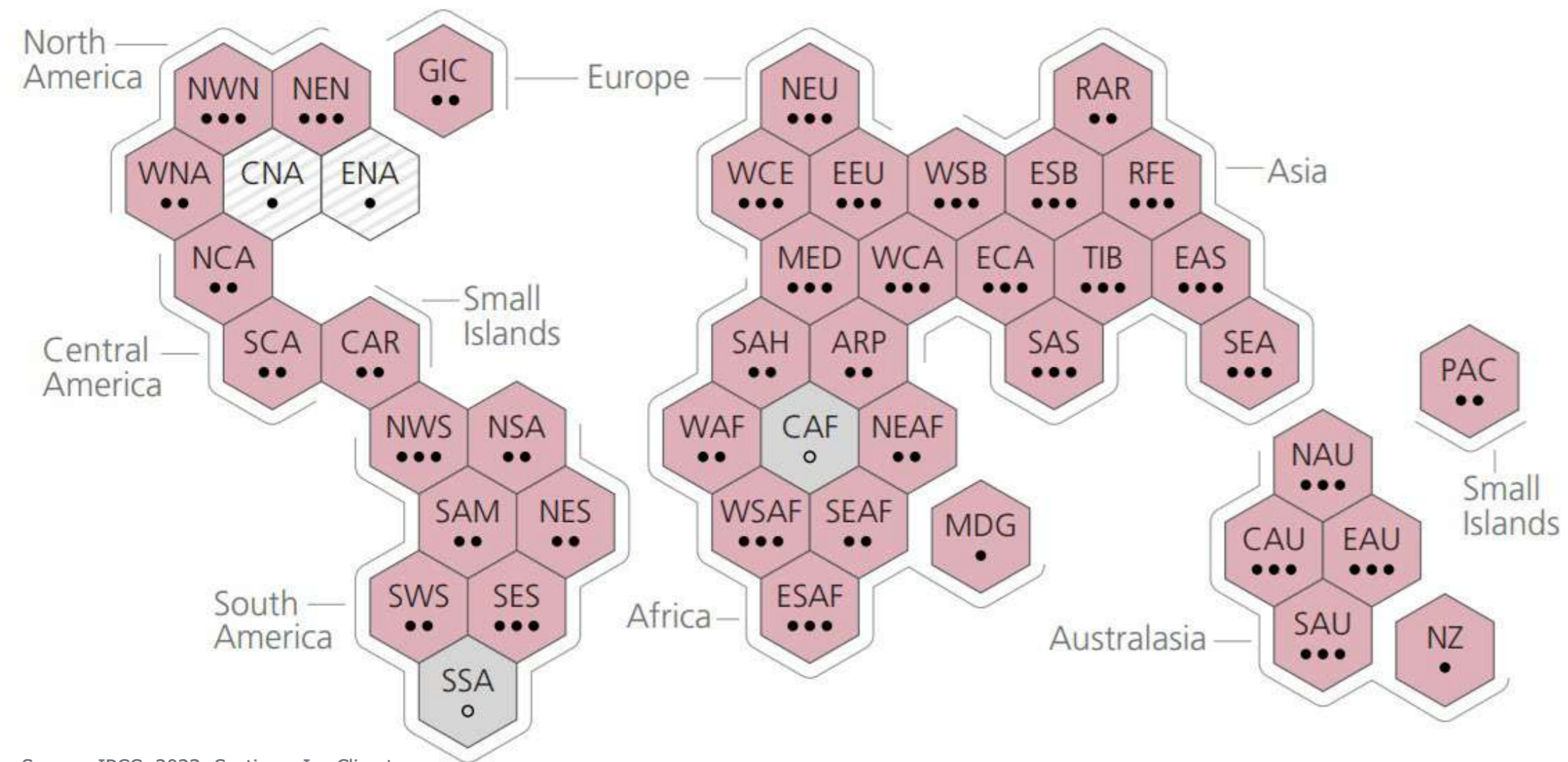
**Confidence in human contribution to the observed change**

- High
- Medium
- Low due to limited agreement
- Low due to limited evidence

**Type of observed change since the 1950s**



**Hot extremes** ← including heatwaves



Source: IPCC, 2023: Sections, In: Climate change 2023: Synthesis Report.

**Over 61,000 excess deaths quantified in Europe due to heat in record summer 2022**

Source: European Climate and Health Observatory ([www.climate-adapt.eea.europa.eu](http://www.climate-adapt.eea.europa.eu)) Accessed at: 2024/05/27



**Over 4% of Summer Mortality in European Cities is Attributable to Urban Heat Islands**

Source: Barcelona Institute for Global Health ([www.isglobal.org](http://www.isglobal.org)) Accessed at: 2024/05/27

Motivation

# Important questions



How much cooler/warmer is a neighbourhood, compared to the climate average?



How extreme is the heat/cold in each neighbourhood?



Which are the cooling/heating acclimatization needs in each neighbourhood?

Preliminary considerations

# AROME ML Downscaling model

## Existing Limitations

- **AROME** downscales global model to **regional scale**
- **WMO stations** are located to have **minimum urban contributions**
- **Netatmo stations** have variability associated to **citizen owned** data and a known **positive bias**

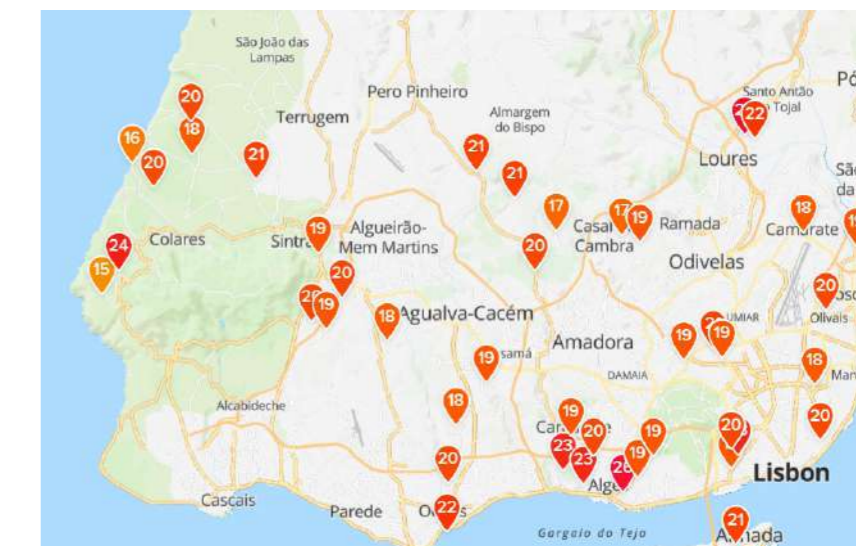
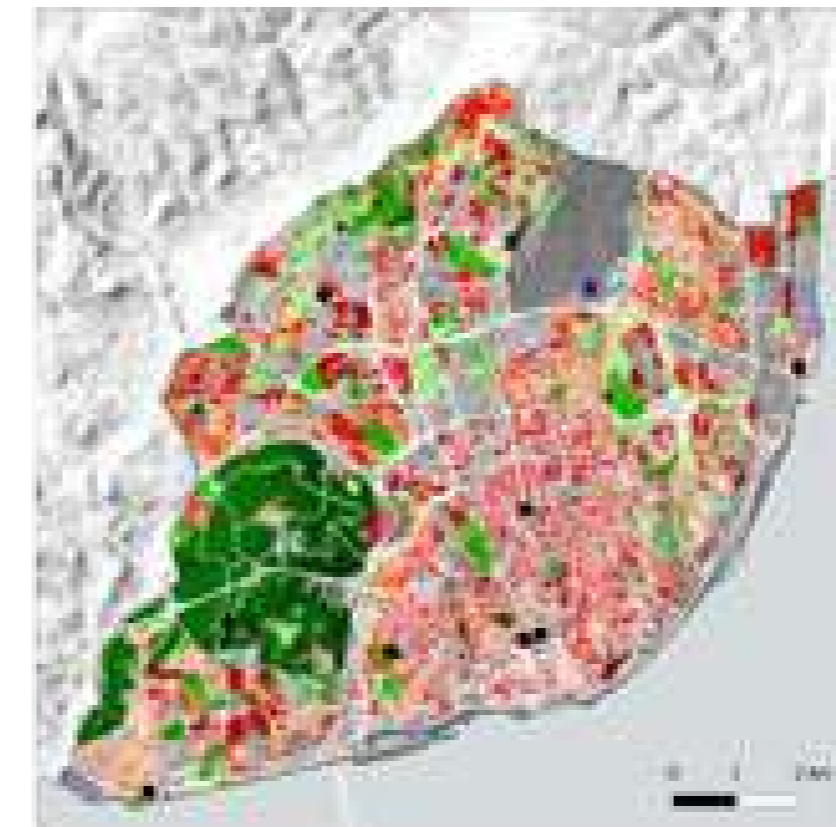
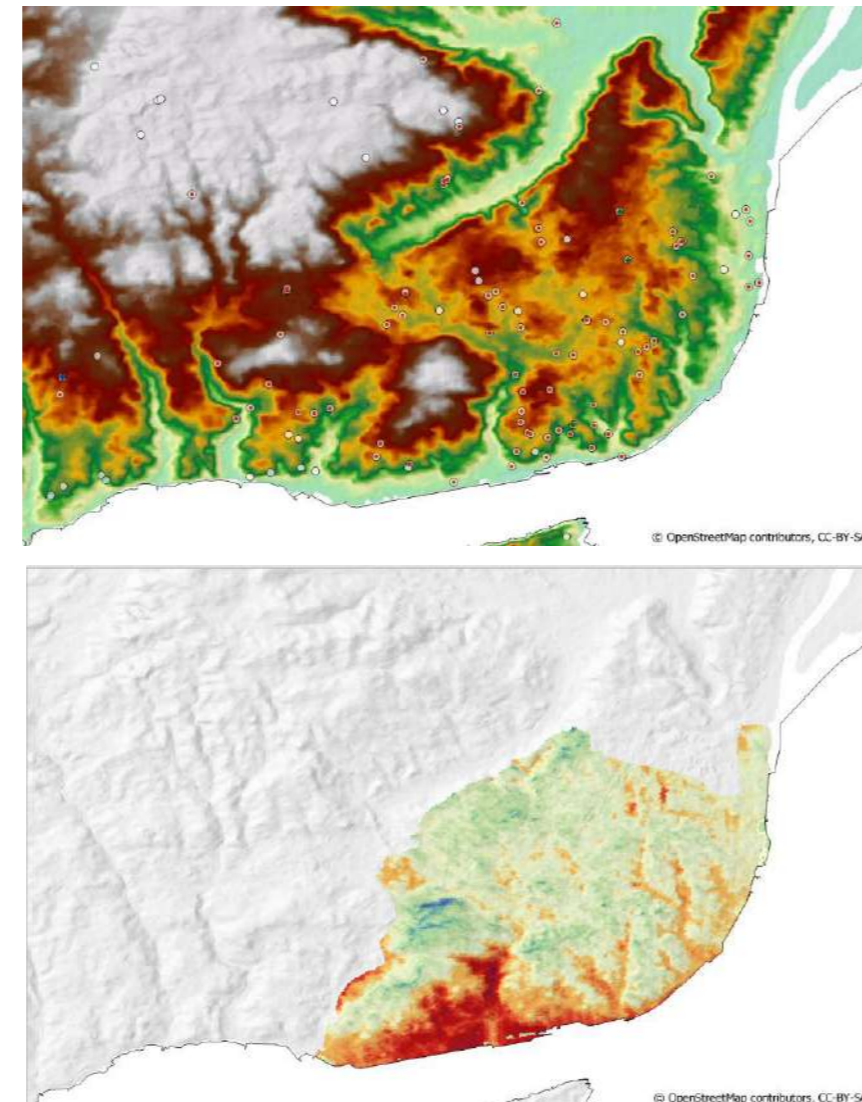
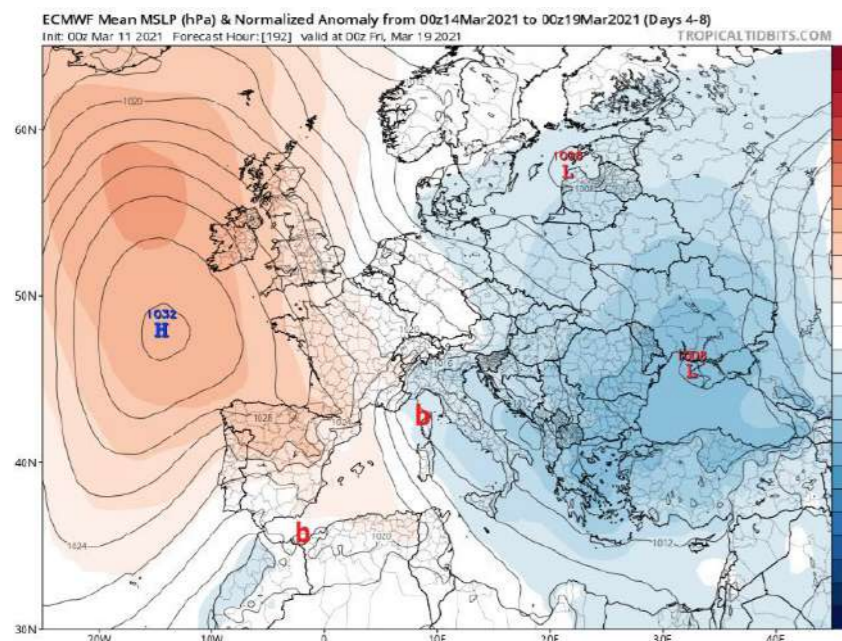
## Goals

- **Downscale AROME** by 10x (from 2.5 Km to 250 m)
- Maintain or Improve the **AROME native error/bias**
- Depict physically **known thermal response** (urban vs. green infrastructure)
- Uphold or improve AROME deviations during **heat/cold extremes**



Preliminary considerations

# Model Formulation



## Background Conditions

Air Temperature  
Mean Sea Level Pressure  
Relative Humidity  
Wind U/V

+

## Landscape Effects

Elevation  
TOPEX (per wind U/V)  
Coast/river distance

+

## Urban Effects

Bowen Ratio (QH/QE)  
Imperviousness  
Tree-cover percentage

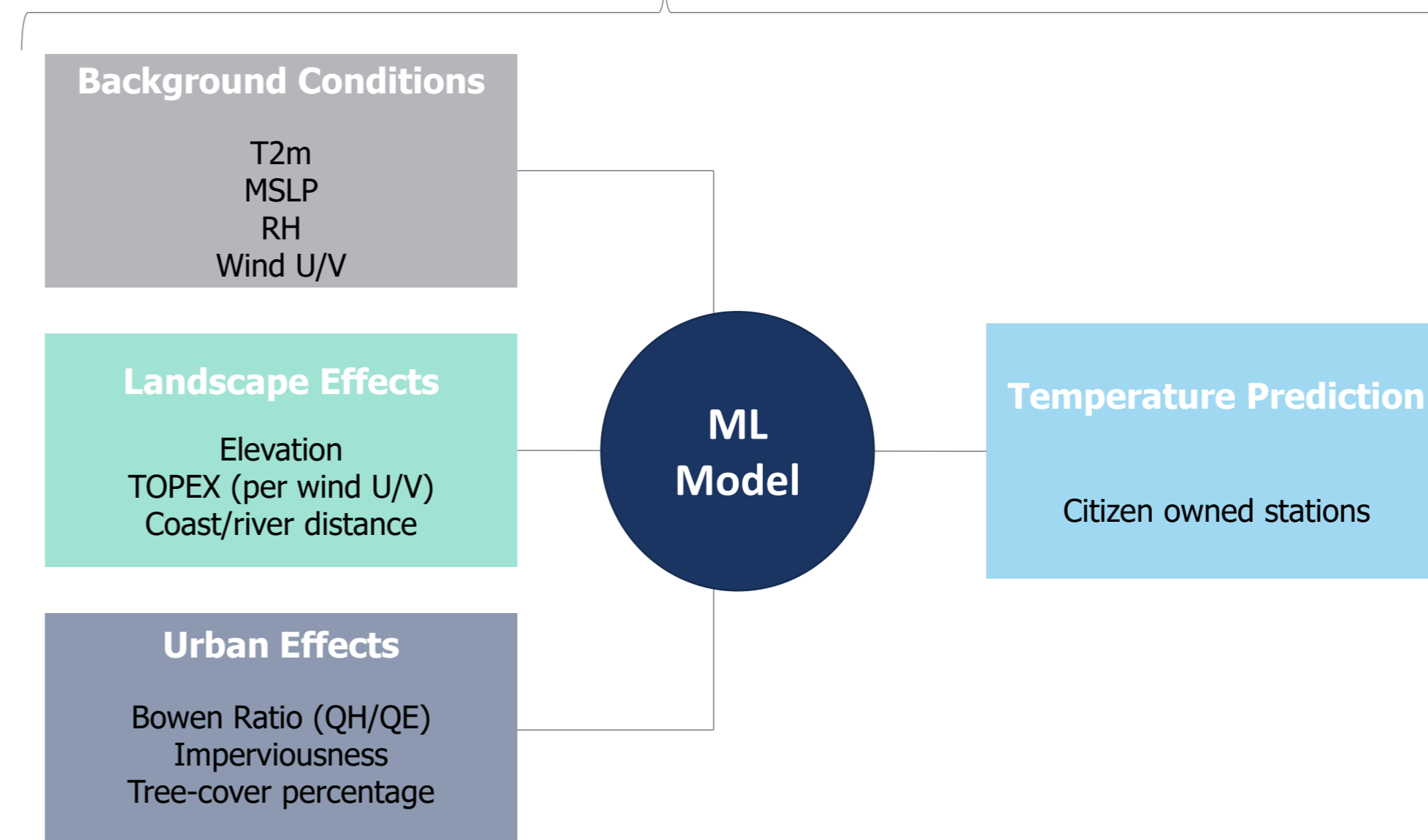
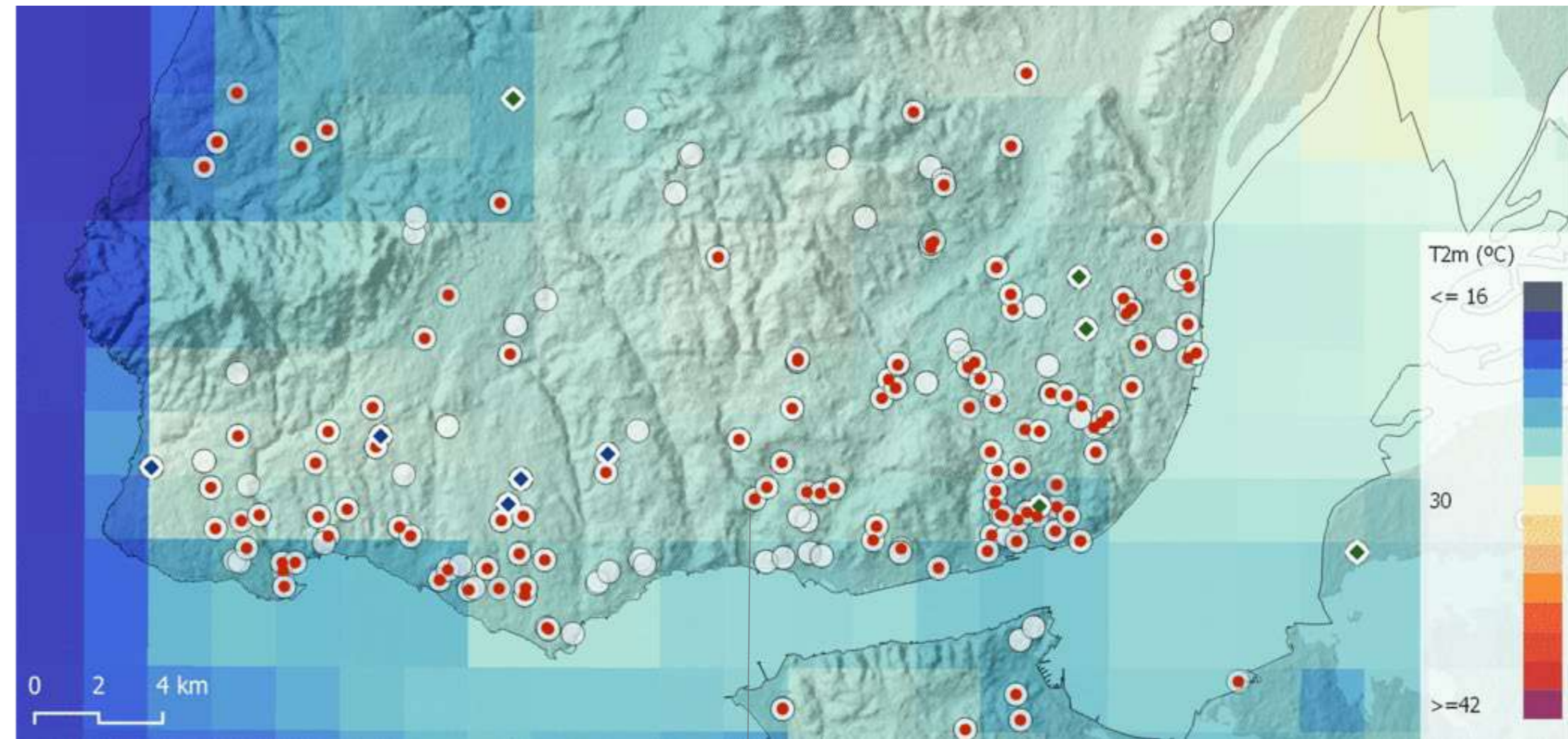
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## Temperature Prediction

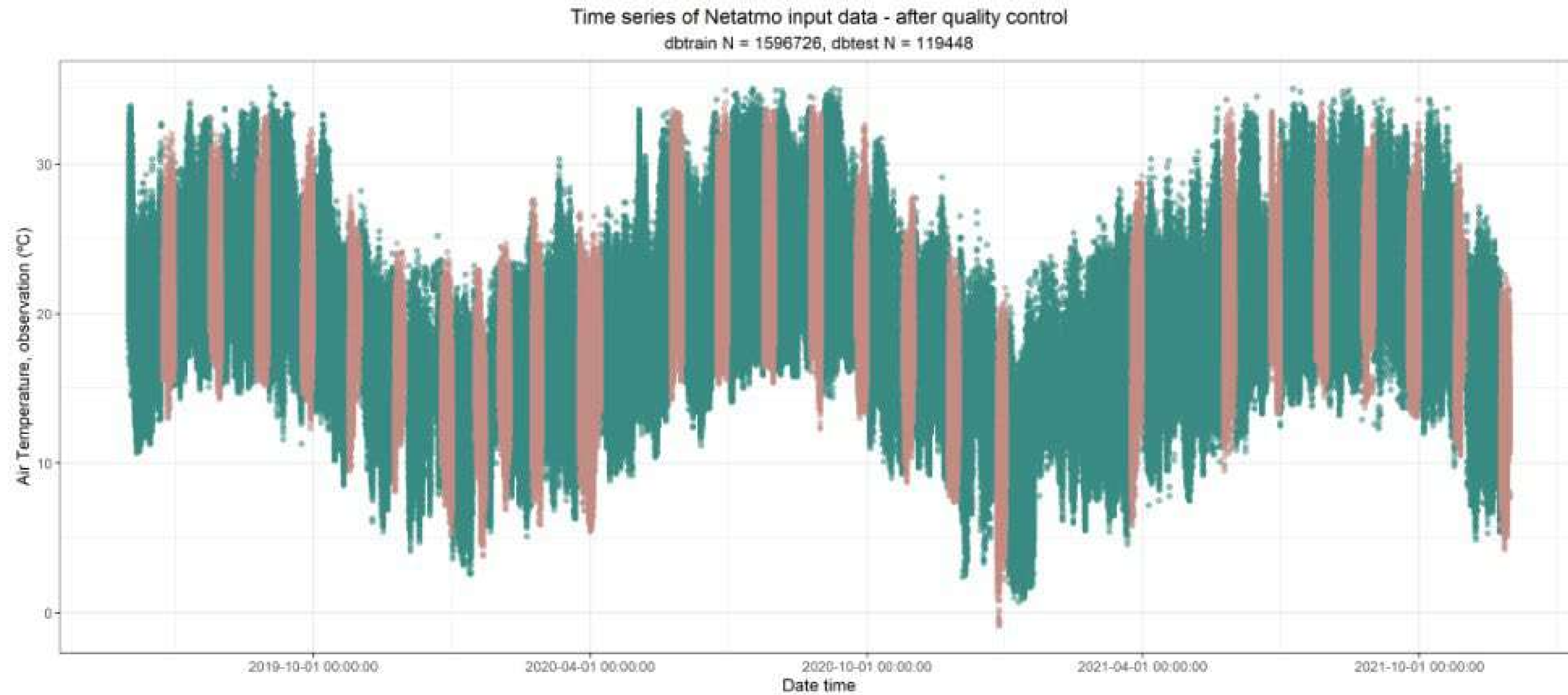
Citizen owned stations  
(Quality Controlled)

Preliminary Considerations

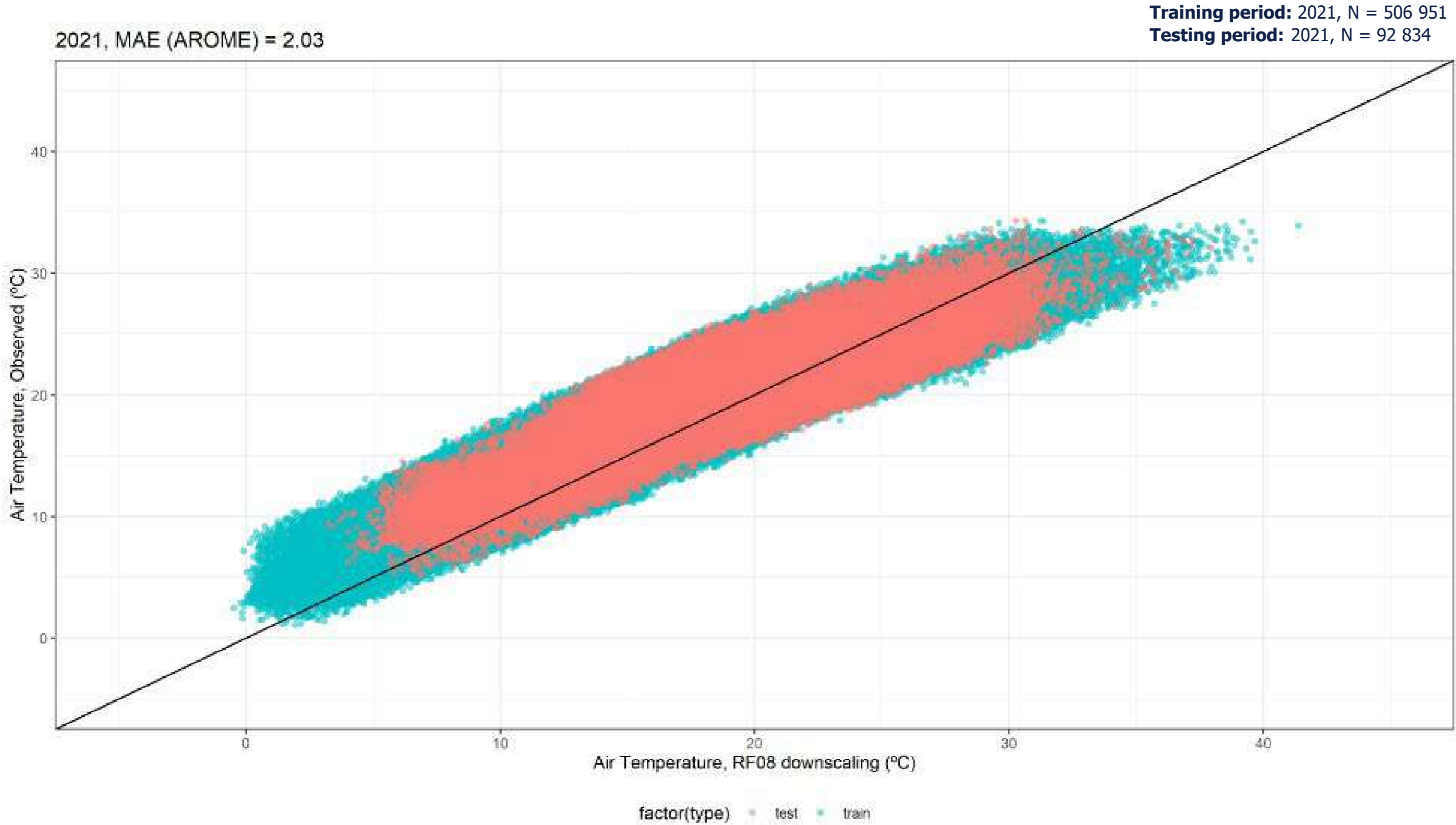
# Model Formulation



# Netatmo data Time Series



# Netatmo temperature error





Results

# Performance RF vs AROME

~ 0.4°C AROME bias reduction,  
~20% accuracy improvement

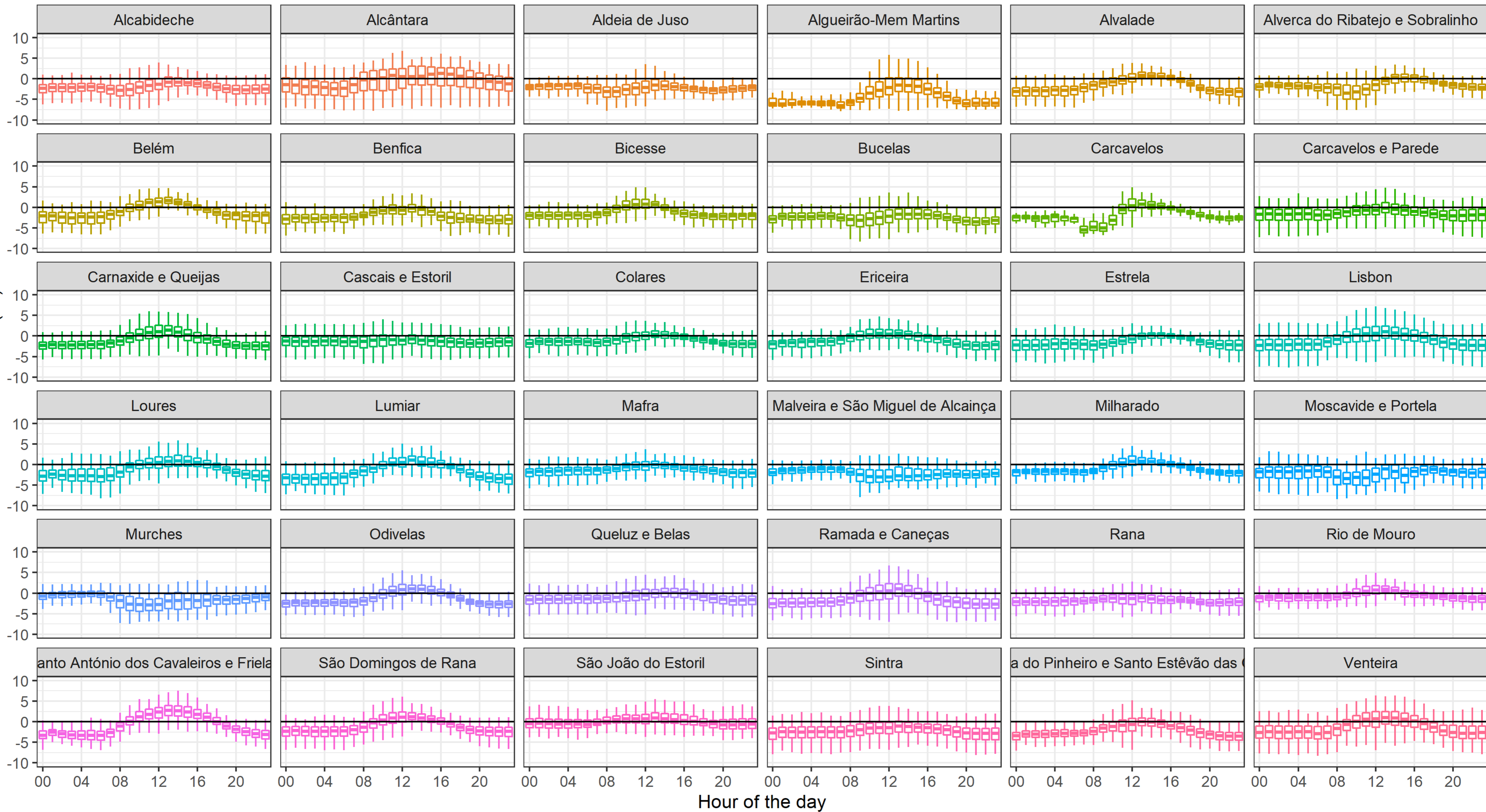
**Training period:** 2021, N = 506 951  
**Testing period:** 2021, N = 92 834

Month (2021)	MAE RF08, train (°C) (N = 506 951)	MAE RF08, test (°C) (N = 92 834)	MAE AROME (°C) (N=599 785)
DJF	1.32	-	1.74
MAM	1.75	1.80	2.12
JJA	1.75	1.67	2.18
SON	1.70	1.55	1.98

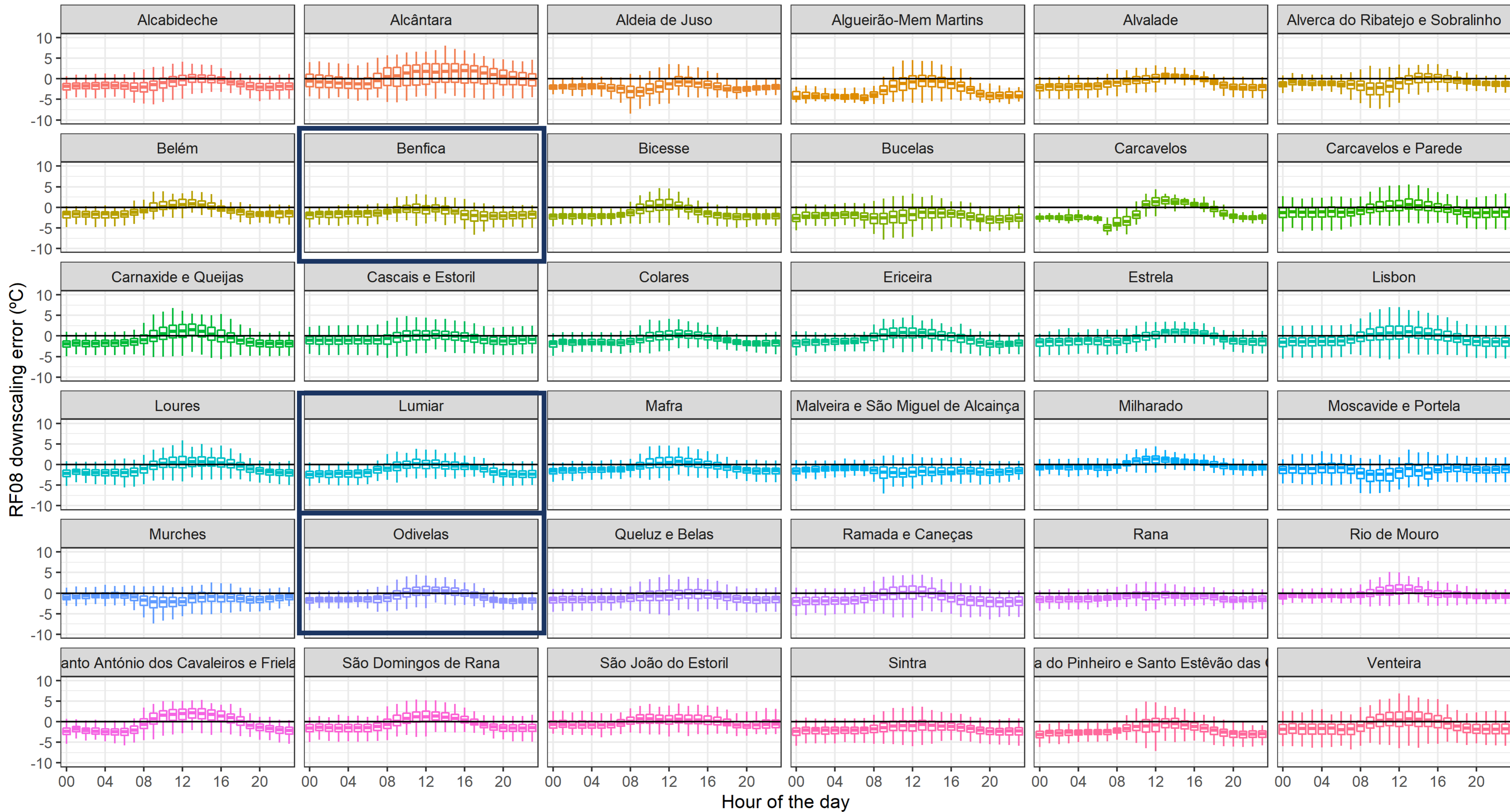
Month (2021)	MAE RF08, train (°C) (N = 506 951)	MAE RF08, test (°C) (N = 92 834)	MAE AROME (°C) (N=599 785)
1	1.29	-	1.80
2	1.36	-	1.68
3	1.64	1.70	2.12
4	1.87	-	2.14
5	1.67	1.91	2.11
6	1.83	1.79	2.19
7	1.75	1.52	2.15
8	1.67	1.78	2.21
9	1.54	1.72	2.11
10	1.72	1.53	1.88
11	1.87	1.34	1.92
12	-	-	-



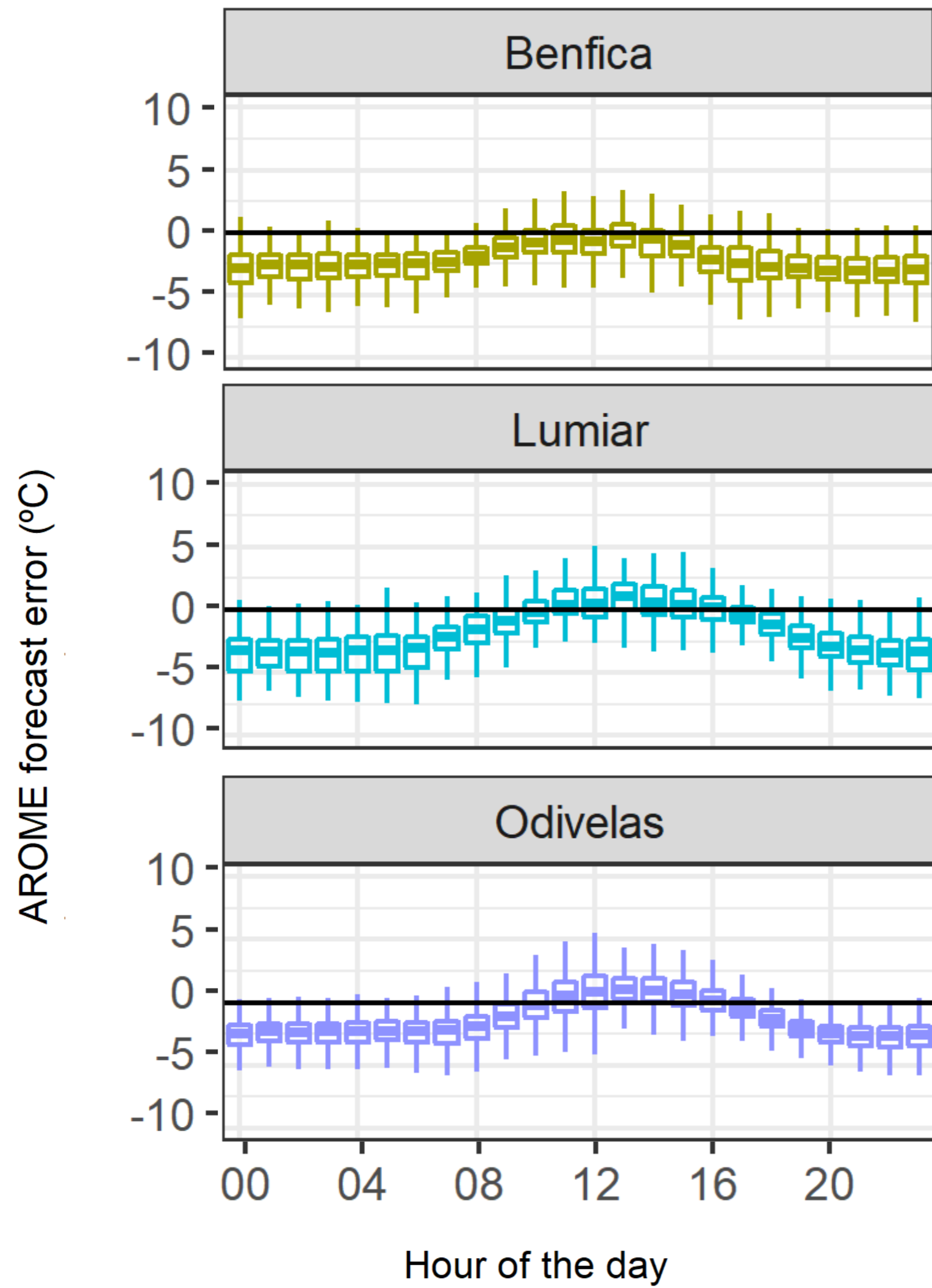
MAE (AROME) = 2.03



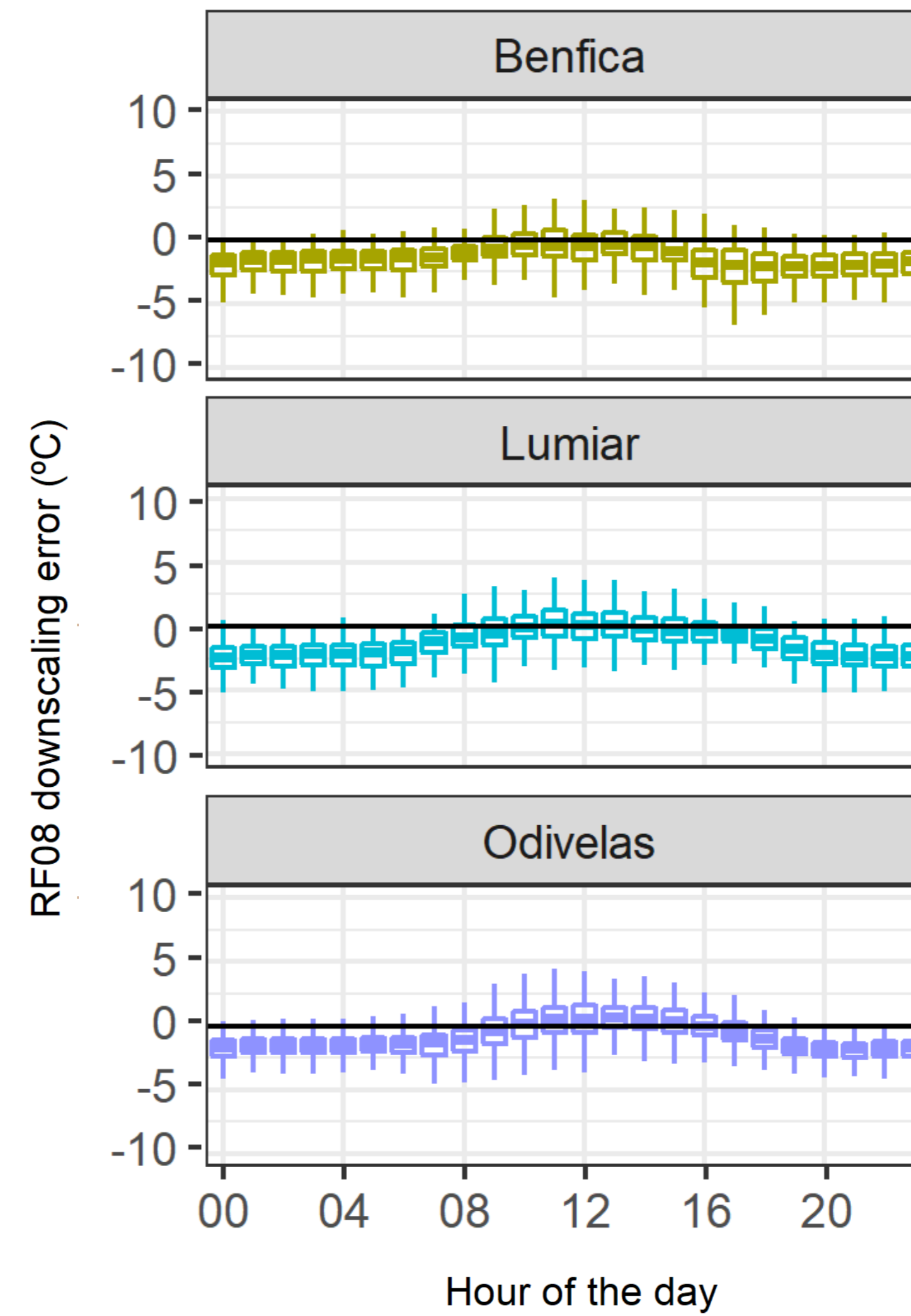
MAE (RF08) = 1.65



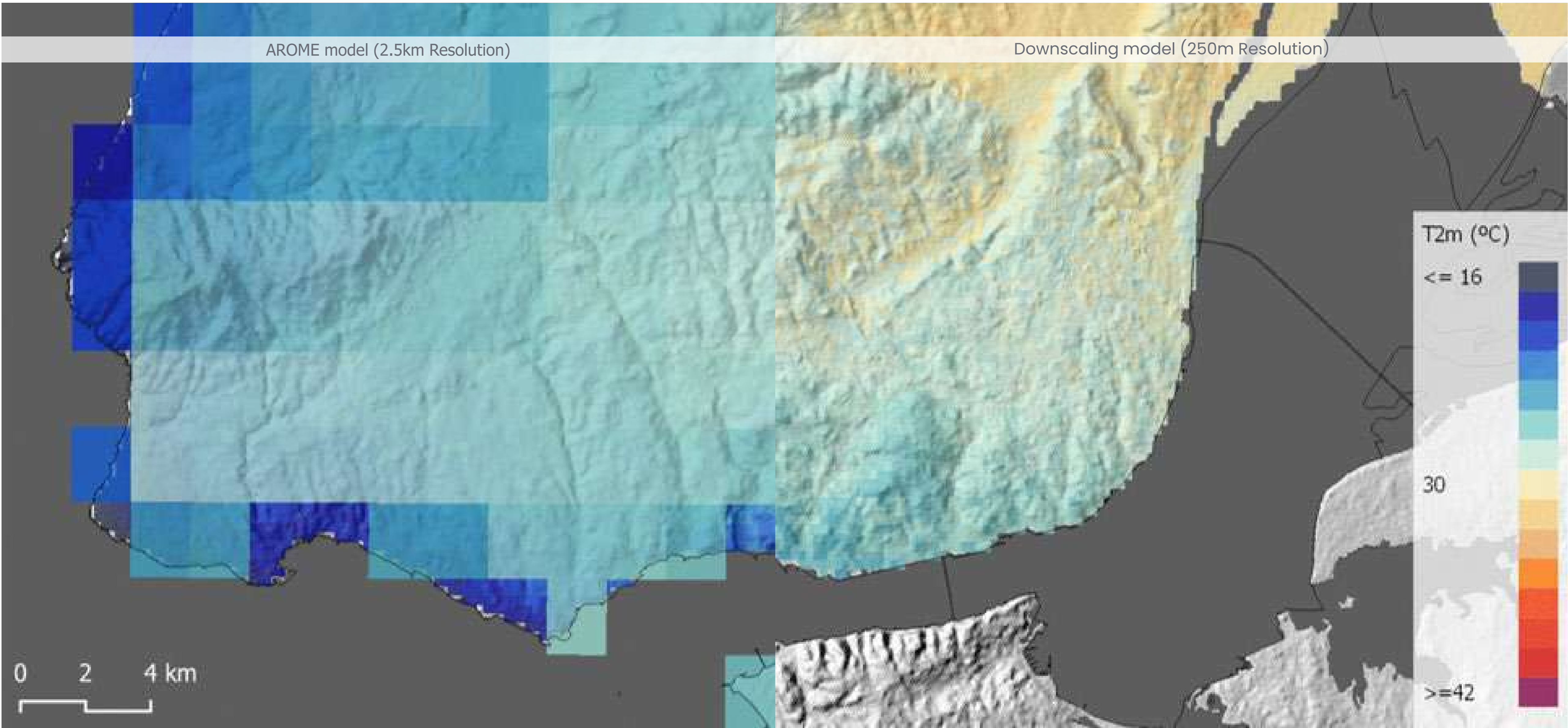
MAE (AROME) = 2.03

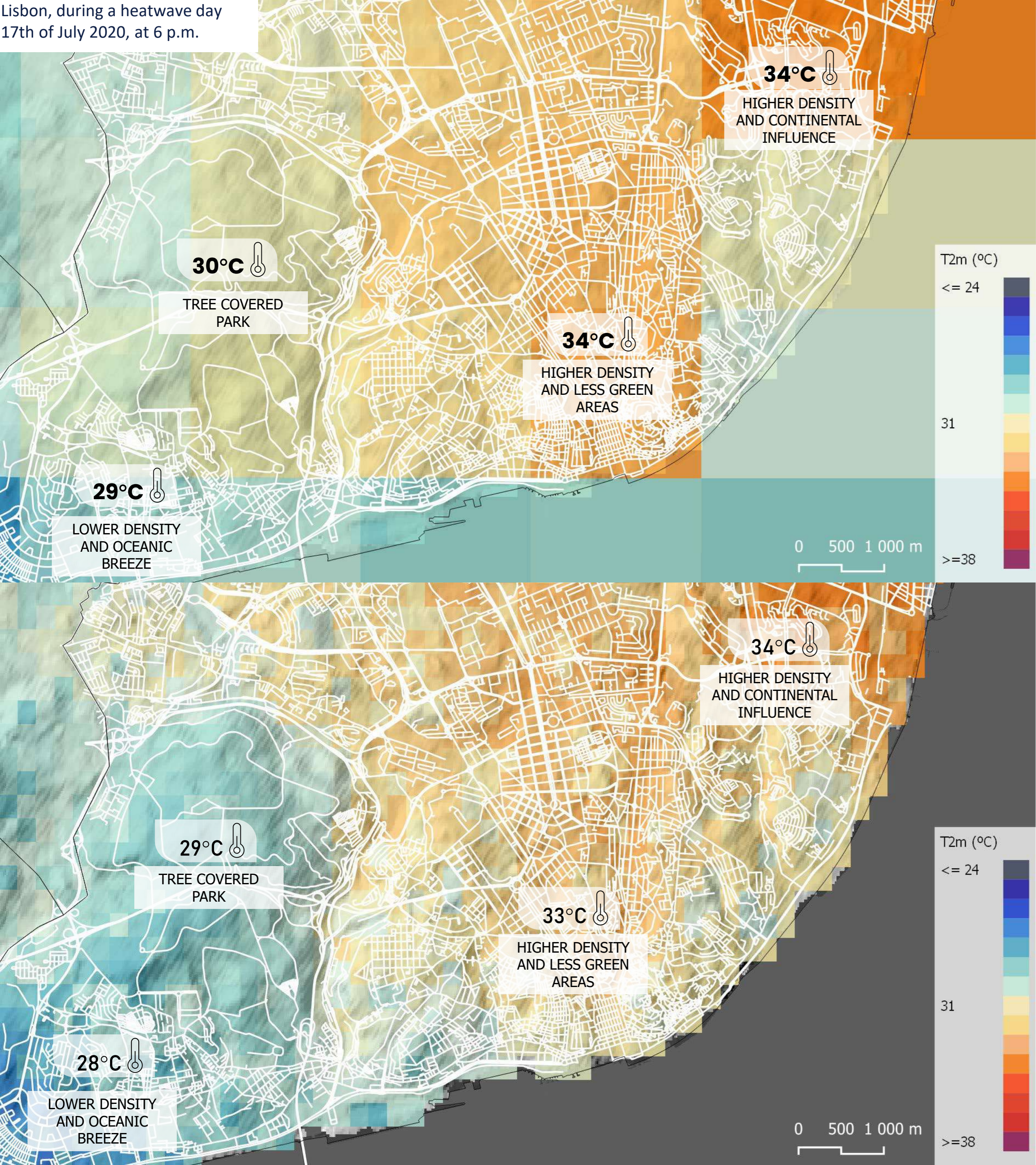


MAE (RF08) = 1.65



# Downscaling



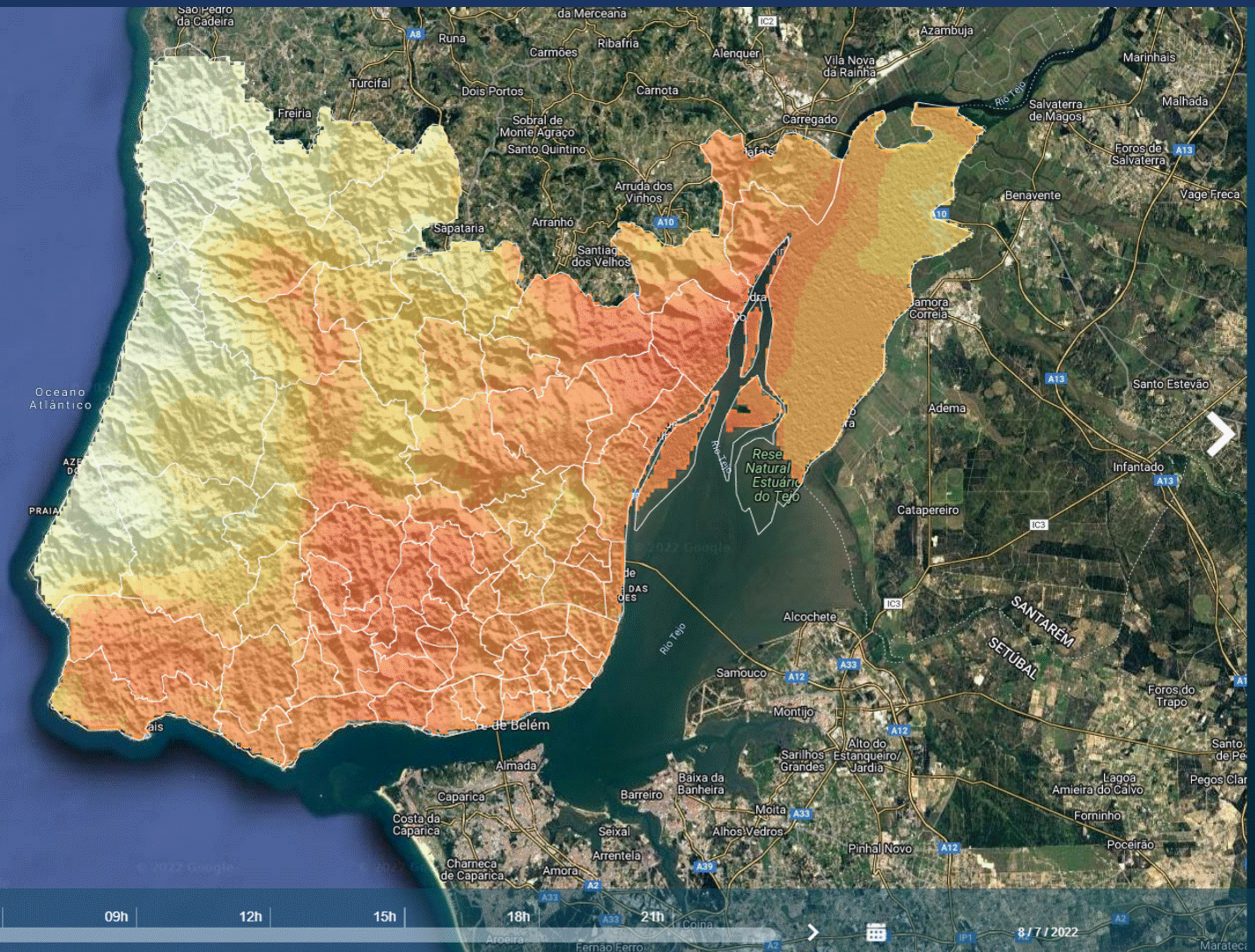


## Results

# Downscaling

- Upsample AROME 10x (from 2.5 Km to 250 m)
- Maintain or Improve the AROME native error/bias
  - Netatmo stations: 20% improvement (0.4 °C)
  - WMO stations: Maintain AROME' s MAE (1.4°C); Slight improvement in nocturnal hours and colder season (~0.2°C)
- Depict physically known thermal response (urban vs. green infrastructure)
  - Mean 0.4°C improvement to AROME in nocturnal underestimation
- Uphold or improve AROME deviations during heat/cold extremes
  - Systematic improvement of at least ~0.2 °C from AROME in four HW/CW events in 2021





Satellite  
 Grey Canvas

High-resolution Temperature Model

Air Temperature ⓘ  
 Thermal Amplitude ⓘ

Learn More

OPACITY

03h 06h 09h 12h 15h 18h 21h 8/7/2022

5 km

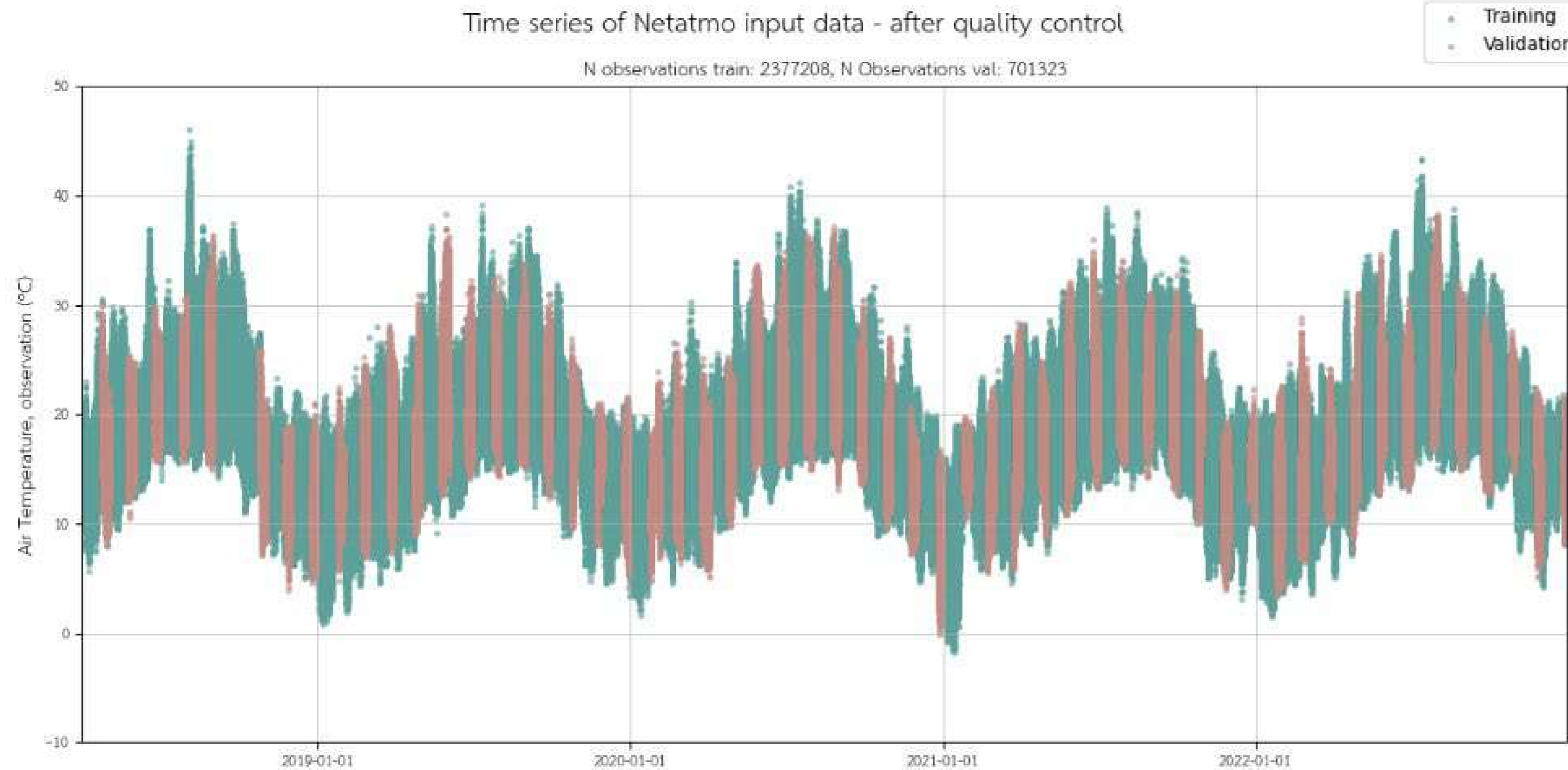
# What Next?





Next Steps

# Retraining Lisbon Model



More data (2018 – 2023)

Updated predictor layers

Data Augmentation for extreme cold/heat days

Predicting AROME bias instead of temperature

Preliminary work shows improving accuracy



Next Steps

# Expanding the concept

Expanding the proof of concept to **Denmark**

More **station density**

Test the **generalization in space**

Data **Augmentation** for extreme **cold/heat days**

Predicting **AROME bias** instead of temperature

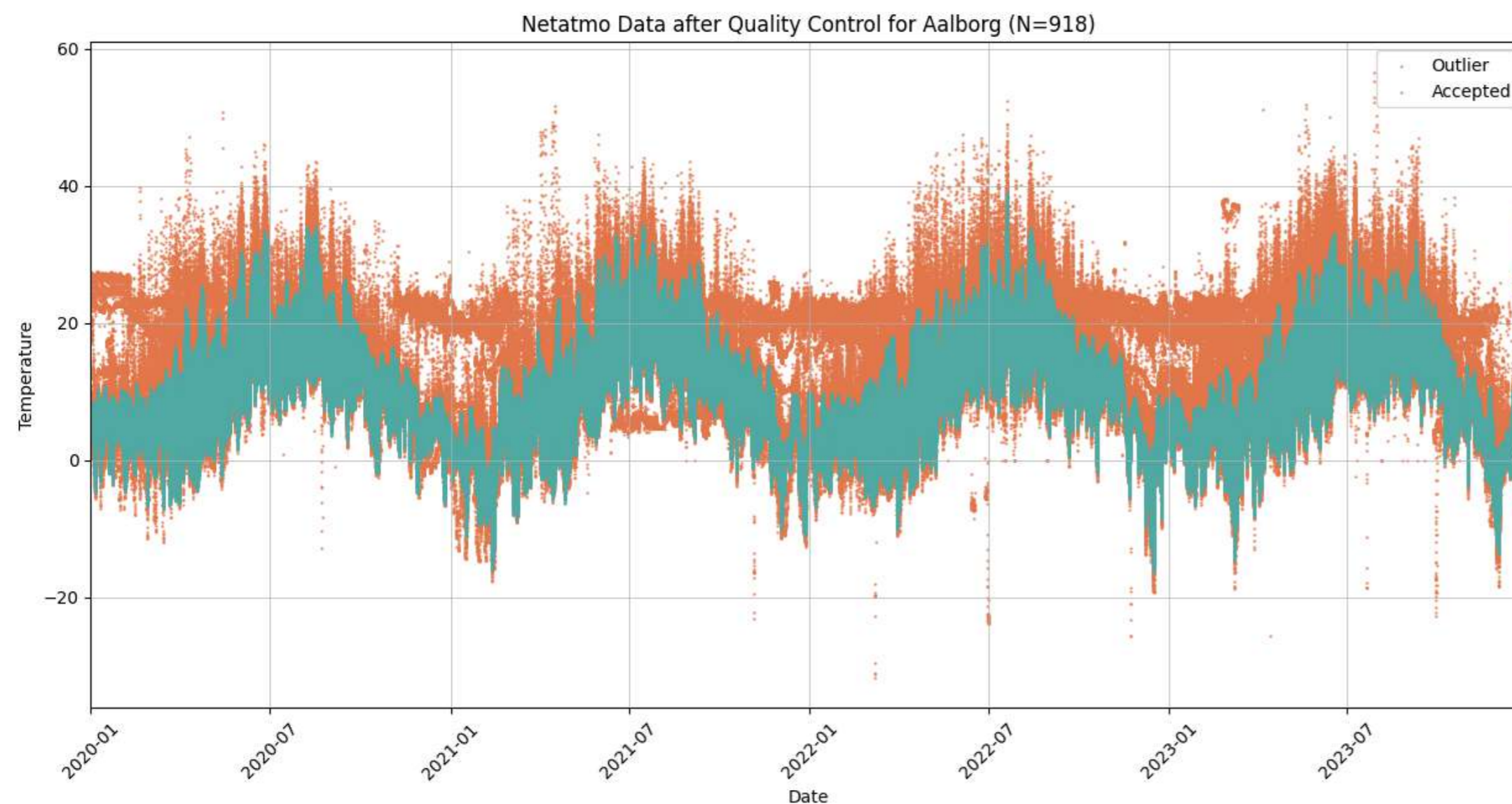
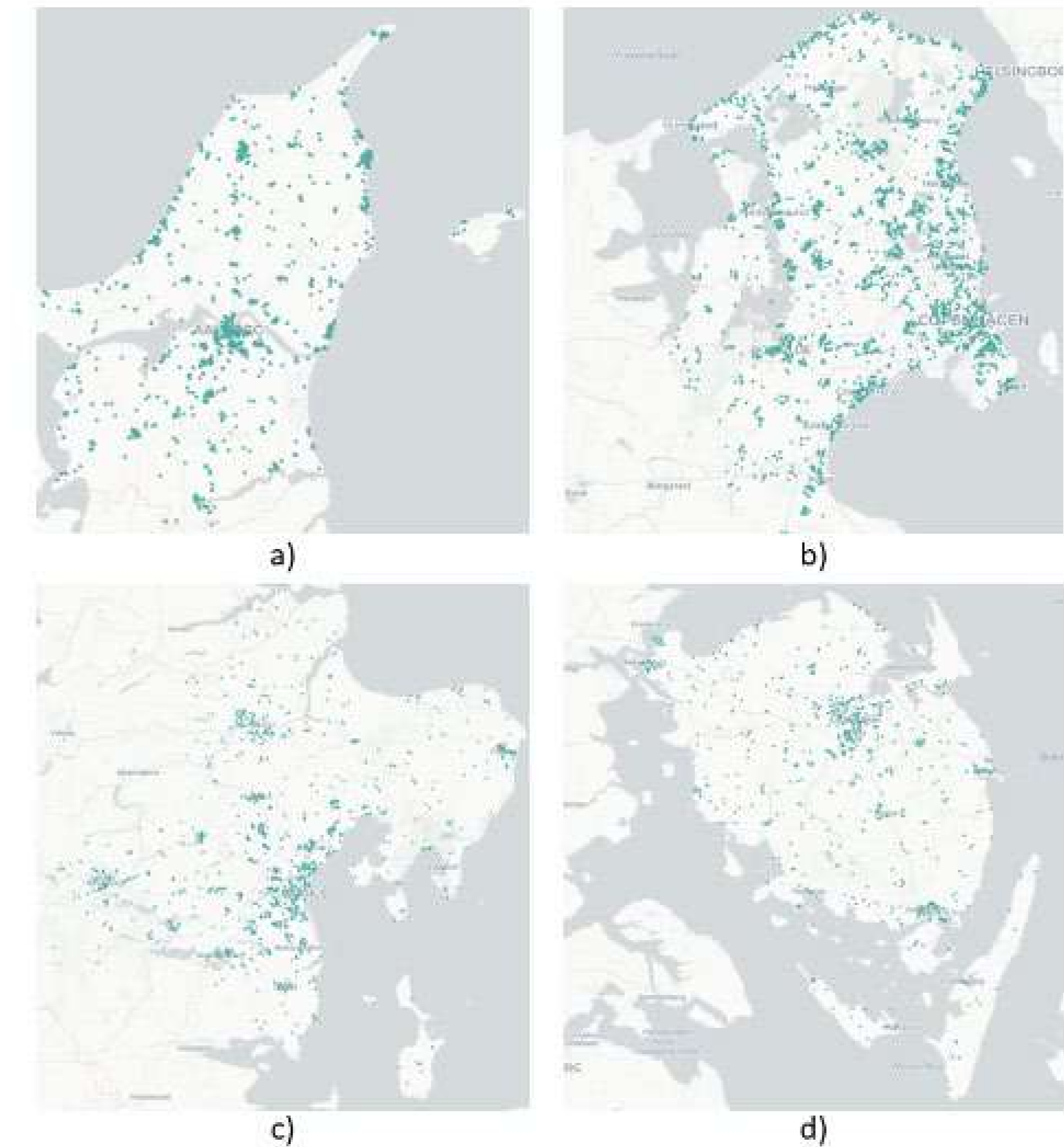


Figure 2. Maps with distribution of Netatmo stations with data within the four year period (2020-2023) for each AoI: a) Aalborg, with 918 stations, b) Copenhagen, with 2223 stations, c) Aarhus, with 1220 stations and d) Odense, with 673 stations.



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